Newton and the Netherlands

How Isaac Newton was Fashioned in the Dutch Republic

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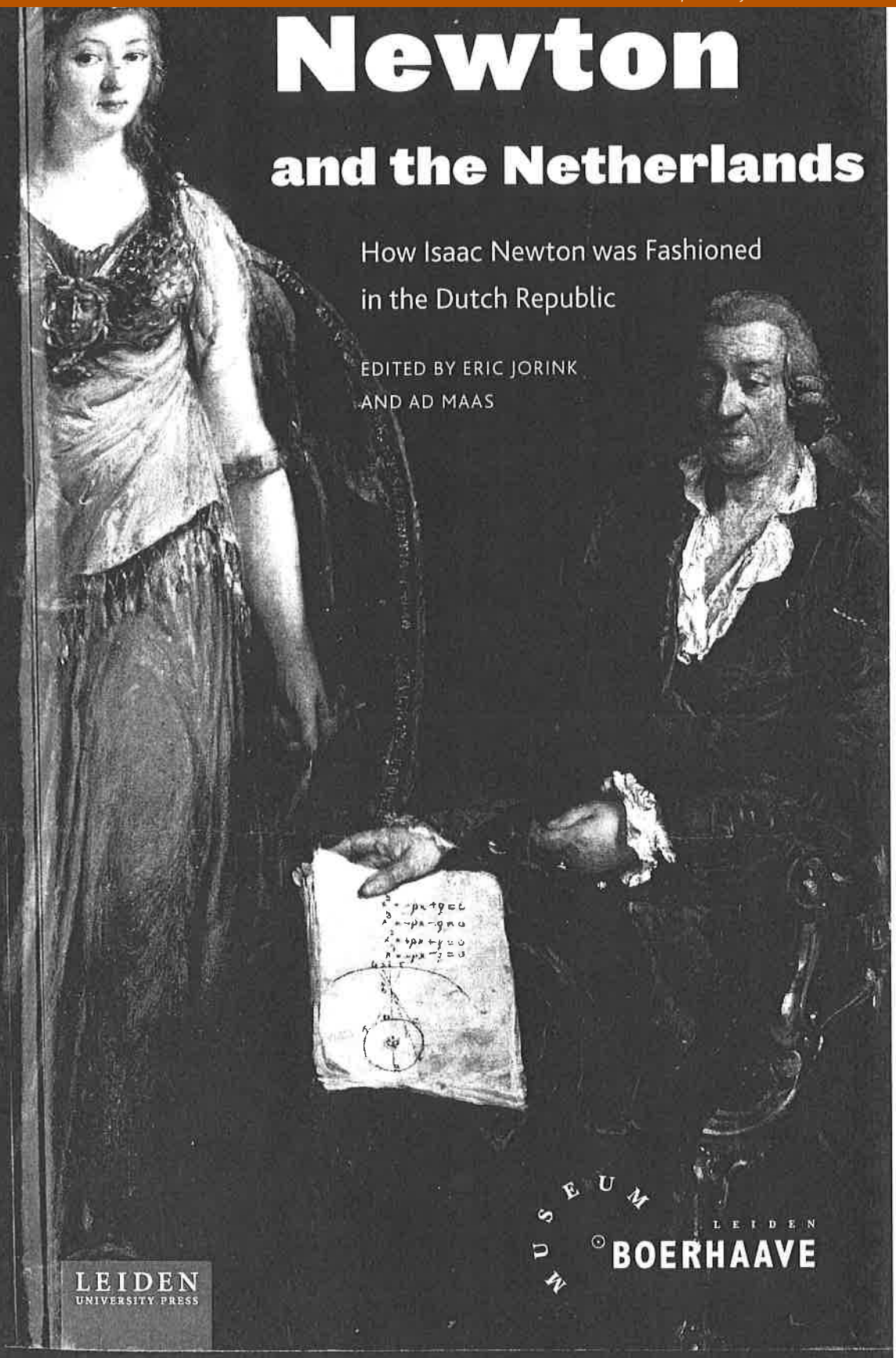

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Servant of Two Masters

Fatio de Duillier between Christiaan Huygens and Isaac Newton

ROB ILIFFE

For a brief period at the end of the seventeenth century, the young Swiss scholar Nicolas Fatio de Duiller (1664–1753) appeared to be on the brink of joining the front rank of mathematicians and natural philosophers. An acknowledged expert in differential and integral calculus at a time when mathematicians were forging foundational techniques in these areas, he was also in possession of a theory of gravitation that synthesized the best elements of the work of the two outstanding natural philosophers of the period, Christiaan Huygens (1629–1695) and Isaac Newton (1642–1727). Indeed, Fatio benefitted from an exceptionally close intellectual relationship between the two men, and was able to work in intimate collaboration with two very different individuals, whose interests spanned a wide range of subjects. Initially Huygens' chief representative in England, he later became a passionate advocate of Newton, whose mathematical and scientific achievements he valued more highly than those of anyone else. A number of historians have suggested that Fatio and Newton had some sort of physical relationship, although there is no evidence for this. However, it is true that the latter exhibited far more concern over the health and well-being of Fatio than for any other individual on record.[1]

Fatio evidently had a plan for a meteoric career and for five years he managed the apparently impossible task of serving two powerful masters. However, he had to balance a requirement to impress and represent his patrons with the need to develop a proper standing in the field. For some time in the early 1690s he was apparently close to having his own theory of gravity appear at the front of a new edition of

the *Principia mathematica* – which was to be completely transformed under his editorship. In this essay I examine the difficulties Fatio encountered in creating and maintaining his own intellectual property in a highly competitive philosophical and mathematical environment. I show that although he enjoyed unrivalled access to Huygens and Newton, he lacked the personal and financial resources to obtain the independence from them that he needed to forge his own career. His early proximity to Huygens enabled him to become the chief representative of the Huygenian philosophy when he went to England in 1687. A few years later, the roles were reversed, and he became the chief source of information for Newton's science and mathematics in the Netherlands.

Fatio's relationship with Huygens has received much less attention than his dealings with Newton, but it is equally interesting. The Dutchman showed a great concern and respect for Fatio over a number of years and he worked closely with the Swiss scholar when the latter stayed with him in 1691. However, their mutual regard lessened when Huygens tried to broker an exchange of integration techniques between Fatio and Gottfried Leibniz (1646–1716) at the end of 1691. Both Fatio and Leibniz had made progress in one of the most difficult areas of calculus, and each had developed techniques that they guarded jealously. However, Fatio's attitude to both his own and Leibniz's achievements was dramatically transformed by his encounter with Newton's mathematical work at the end of 1691, and his views of Leibniz's originality and intellectual virtue, already less than positive, were severely diminished as a result. To his chagrin, Huygens failed to facilitate communication between the younger scholars and he died in 1695, having played a major role in instigating the great priority dispute over the invention of the calculus that was soon to erupt between Leibniz and Newton.

The prodigy

Born into a wealthy family in 1664, Fatio attended the Académie de Genève, where his talent was nurtured by John-Robert Chouet (1642–1731), rector of the Academy from 1679. Chouet was a pronounced Cartesian whose influence on the curriculum resulted in a much greater emphasis on physics and mathematics. With the support of Chouet Fatio made his way to Paris in early 1683, where he learned sophisticated astronomical theory and practice with the director of the Observatoire, Jean-Dominique Cassini (1625–1712). In 1685 Chouet communicated Fatio's work on the zodiacal light recently discovered by Cassini to the journal *Les nouvelles de la république*, and its editor, Pierre Bayle (1647–1706), commented on Fatio's excellent mathematical training. Cassini himself commented that Fatio had all the qualities essential to a gentleman.[2]

Although it went against the wishes of his parents, Fatio set out to forge an identity as a major player in the scientific Republic of Letters. A chance encounter offered him a very different source of patronage and he became associated both with the Dutch States-General and with the court of William of Orange (1650–1702). Having returned to his father's estate in 1685 as a result of the Revocation of the Edict of Nantes, he came into conversation with a Count Fenil, who apparently told Fatio of a plan to kidnap the prince. Fatio relayed this information to Gilbert Burnet (1643–1715), by then a close confidant of William. Fatio travelled back to Holland with Burnet in the spring of 1686, and as a result of his information the States-General tried to set up a chair in mathematics for Fatio. This idea, resurrected a few times over the following decade, never came to fruition.[3]

Nevertheless, Fatio's sojourn in the Netherlands did enable him to meet Christiaan Huygens at The Hague, and for a number of months over the winter of 1686–1687 they worked closely together on various topics, including the shape of snowflakes and finding tangents to complex curves. Huygens recognized Fatio as an outstandingly talented younger mathematician whose work and career he could support, and got Fatio to locate and publish errors in the recently published works on tangents (i.e. differentiation techniques) of Ehrenfred Walther von Tschirnhaus (1651–1708). This brought Fatio to the attention of the mathematical community but it was his work on the 'inverse problem of tangents' (the solution of differential equations, i.e. finding the equation of a curve whose tangent is given), whose results he sent in a letter to Huygens in June 1687, that was most significant and which would soon bring him into conflict with Leibniz.[4]

At some point early in 1687 Fatio decided to visit England, a move prompted both by a delay in organizing his professorial position, and also by a wish to acquire the patronage of Robert Boyle (1627–1691). He already cut an impressive figure, and Burnet told Boyle in early 1687 that Fatio was 'one of the greatest men of this age [who] seems born to carry learning far beyond what it has attained'. Fatio duly met

Boyle and learned of the content of the imminent *Principia mathematica*. When it appeared in the summer it was the talk of the town. Its first readers were stunned by its contents, for Newton's three laws of motion and his theory of universal gravitation united the laws that governed celestial and terrestrial phenomena and accounted for the tides, the shape of the Earth and the paths of comets and planets. In the same letter in which he revealed his solution to the inverse method of tangents, Fatio informed Huygens that he had already been to three meetings of the Royal Society and that he had been reproached for being too much of a Cartesian. Fatio clearly wrote as a client when he remarked that Newton should have consulted Huygens over the principle of attraction, and he reminded Huygens that while in Holland he had stated that the latter's explanation of gravity would give sufficiently probable reasons to explain the tides. In his well-known reply to Fatio, Huygens noted that he hoped Newton did not make use of the doctrine of attractions.[5]

Fatio sought to stay in London but his father urged him to return to Geneva and apparently withdrew financial aid, an action that would have serious consequences for Fatio's later career. Having realized that the Royal Society did not give financial support for research, even to scholars as talented as himself, Fatio redoubled his efforts to procure patronage, and wrote to Boyle in January 1688 to see if he could gain employment as a tutor. In May 1688 he informed Huygens that he had made plans to stay in England for another year but this involved tutoring the son of one of his friends. It would be preferable, he said, if at the end of this period he could return to work with Huygens at The Hague.[6]

As England lurched towards political revolution in the summer and autumn, Fatio spent much of his time as a tutor, working when he could on mathematical problems and his theory of gravity. He gave a talk on the latter subject at the Royal Society in June 1688, claiming that his notions had been 'embraced' by Huygens, although in later notes he remarked that he had also added his own thoughts. In July he read a more detailed account of the theory at one of their meetings, explaining gravity in terms of an aetherial vortex that revolved around the Earth every eighty-five minutes. As before, it was difficult to separate his own views from those of Huygens, although he told his audience that he was essentially presenting Huygens' theory. Over the next year and a half he would develop a much more extensive theory of his own, this time incorporating a number of Newtonian elements.[7]

Ironically, just as news filtered through from Fatio about the contents of the *Principia*, Huygens completed a major rewriting of a theory of gravitation that he had initially composed in 1669. He received a presentation copy of Newton's work in September or October 1687 and immediately reconsidered his explanations of gravitation and the shape of the Earth. In December 1687 he endorsed Newton's claim that he had destroyed Cartesian vortices and lauded Newton for his treatment of comets. Throughout 1688 he spent a great deal of time immersed in the *Principia*, and he praised Newton for showing that gravitation was centripetal and operated according to an inverse square law that retained planets in elliptical orbits. Nevertheless, his commitment to the ontological and epistemological demands of the mechanical philosophy meant that he could not allow the existence of an immaterial *universal* gravitation, especially one that operated between tiny particles separated at incomprehensibly large distances. At the same time, he filtered data from the ongoing trials of his pendulum clocks aboard the Dutch East India Company (Vereenigde Oost-Indische Compagnie [VOC]) ship *Alkmaar*, which provided him with information about the shape of the Earth suggesting that the planet was an oblate spheroid, but not as flat as Newton had suggested. He referred to this data in a report written to the directors of the VOC in April 1688.[8]

Fatio's prospects improved in January 1689, in the immediate wake of the Glorious Revolution, when the author of the *Principia* came down to London in a political capacity. Newton had stood as a candidate for the Convention (as one of the two representatives of the university) and against the odds, had won a seat. Probably no earlier than the spring, he made contact with Fatio and they undoubtedly discussed a range of issues in optics, mechanics and mathematics. The subject of alchemy formed a significant part of their discussions and indeed they corresponded on the subject, although these letters are now lost. By October Newton was sufficiently familiar with Fatio that he could confide to him exceptionally impolitic comments about Boyle, and he asked what must have been a delighted Fatio whether he could lodge with him during the imminent session of Parliament.[9]

Newton and Fatio were also close at this time to the radical Whig MP John Hampden (1631–1695), a remarkable man who had studied with Richard Simon (1638–1712) while in Paris in the early 1680s, and who

had later sponsored some of his researches. Fatio and Hampden were in Newton's company on many occasions over the summer, and were instrumental in pushing for Newton's ultimately unsuccessful attempt to become provost of King's College, Cambridge, in the summer of 1689. By November, Fatio was an ardent admirer of Newton, describing him to Chouet in November as *'le plus honnête homme'* he had met, and the ablest mathematician who had ever lived. If he had 100,000 écus, he told Chouet, he would erect great statues and a monument to Newton. Fatio lodged in Hampden's London residence over the winter of 1689/90, called Hampden his 'intimate friend', and earned a small salary from tutoring one of Hampden's nephews. He would remain in close contact with Hampden for the following two years.[10]

The Dutch contribution to the Glorious Revolution provided further patronage opportunities. In the first place, Fatio's champion, Gilbert Burnet, was one of the chief advisors to William of Orange, and Fatio could look forward with confidence to Burnet's support after the Revolution. Secondly, as William quickly gained control in England and Scotland at the end of 1688, Christiaan Huygens realized that the central position of his brother, Constantijn (1628–1697) in William's entourage paved the way for his own translation to London. In the middle of November 1688 he told Constantijn that he was pleased with the progress of the expedition and on 20 December (O.S.) he confessed how delighted he was that the venture had turned out so well. He outlined his desire to move to England, and emphasised his wish to meet Newton, a man who had made 'beautiful discoveries'. In March, with the overwhelming success of the Williamite revolution now ensured, Huygens told his brother that he would be leaving for England before long, not for the coronation but in order to see what was going on in the scientific world. There was little chance of conversation on scientific matters in the Netherlands, and he told Constantijn that he had spent the previous days in Leiden trying to publish treatises on light and gravity that he had been polishing off over the winter. However, paper was prohibitively dear and the world seemed more interested in political news.[11]

Huygens arrived at Harwich on 1 June 1689 and was in London (lodging with Constantijn at Hampton Court) five days later. On 10 June (O.S.) he met Boyle, then in the midst of his fascination with the alchemical 'red earth', and indeed the possibility of turning lead into gold featured heavily in their conversation. He met Newton and Fatio at the meeting of the Royal Society on 12 June (O.S.) where he gave presentations on his theory of gravity and on birefringence in Iceland crystal (calcite). He and Newton discussed the nature of light, doubtless smoothing over the differences that had emerged when Newton had first published his theory of light and colour in the early 1670s. At this encounter, and probably at another on 30 June (O.S.) they must have discussed their mutual theories of gravity as well as various concepts and propositions in the *Principia.* In July Fatio, Newton and Christiaan rode from Hampton Court to London (presumably having met the day before), and in August Newton sent Huygens two small demonstrations on motion in resisting media. The July meeting had been convened in connection with the efforts by Fatio and John Hampden to enlist the support of the Huygens brothers in the great quest to gain Newton the provostship at King's College. Through Constantijn, they gained the support of William himself, but as we have seen, this had little effect on the outcome. Huygens returned to the Netherlands at the end of August, and for a while tried to obtain a senior administrative position. Despite the efforts of Constantijn, William apparently decided that Christiaan was unsuitable for such a position.[12]

The intermediary

The personal encounter with Newton forced Huygens to once more alter his theories of light and gravity, and he composed an extensive 'Addition' to his recast theory of gravity. Here he referred to the way that the VOC data affected his account of the shape of the Earth; he argued that it supported his own theory rather than Newton's, though he did not rule out the possibility that further data would give more robust support for universal gravitation. He completed the revisions to his treatises on light and gravity in The Hague, in a location that was preferable to the 'overly melancholic solitude' of Hofwijk, the country estate of the Huygens family at Voorburg. The single tome consisting of the *Discours sur la cause de la pesanteur* and the *Traité de la lumière* was published at the end of January 1690 and he immediately dispatched copies to English scholars. In the volume intended for Fatio, Huygens marked two passages in the 'Addition' in which he denied there could be a mechanical cause of universal gravitation, and where he asserted his wave theory of light. He told Fatio that he had crafted his comments in such a way that he believed Newton would not take them badly, and pointed out that Fatio would almost certainly need to

help Newton with the French.[13] In his letter Huygens remarked on the fact that he had not heard from Fatio for a substantial period of time, and indeed, Fatio was already providing indications of his unreliability as a correspondent. Constantijn was unable to locate Fatio when he tried to deliver Fatio's copy of the *Traité* to him in February 1690. Fatio was no longer at the Suffolk Street address where he had been when Christiaan had visited him in 1689, and was by now staying with Hampden. The other copies ultimately reached their intended recipients through William Stanley, Queen Mary's clerk of the closet and Christiaan's major contact in London. Believing that Fatio was lost somewhere in Europe, Huygens showed extraordinary concern for his protégé, telling Constantijn that if he failed to hear about Fatio from Stanley, he (Christiaan) would have to write directly to Newton.[14]

On 24 February 1690 Fatio told Huygens that he had read his work (actually Hampden's copy) a number of times and with a singular pleasure. With reference to Huygens' overtly probabilistic stance, he remarked that it would be a shame if the theory were not true. However, the same letter contained a new theory of his own, elements of which must have been composed in great speed after reading Huygens' work. Two days later he read the letter as a paper at a meeting of the Royal Society. Fatio had removed the notion of a circulating vortex and had injected a number of Newtonian elements into his new theory, in particular the notion that tiny, secondary particles were 'agitated' in every direction. These particles were subject to innumerable impacts caused by being first attracted and then reflected less powerfully. Their interaction with the hard, massive parts of macro-objects ultimately gave rise to the observed inverse square law. On 19 March he got the endorsing signatures of Edmond Halley (1656–1742) and Newton on his manuscript of the theory, and later added that of Huygens.[15]

Fatio also relayed Newton's views to Huygens, especially regarding the question of what Newton thought about the cause of gravity. He told Huygens that Newton would take perfectly well (*'recevra parfaitement bien'*) what Huygens had said about his work and claimed that Newton had 'been ready on many occasions to correct his book on the topics about which we have spoken; I can't sufficiently admire his dexterity, especially in the places you attack'. Fatio showed a fair degree of presumption in speaking on behalf of Newton, since the latter had recently returned to Cambridge after his stint as an MP. Nevertheless, Newton had told Fatio he was about to return to London, and on the same day that he wrote to Huygens Fatio passed on to Newton Huygens' sound advice about the need to read the French texts in London with himself. Newton arrived in London on about 10 March and remained for over a month. He almost certainly lodged with Fatio and the two of them worked closely on various topics. Fatio relayed the tenets of the *Discours* to Newton and they collaborated in compiling a list of errata from the *Principia*.[16]

Huygens' response to Fatio's theory of gravity was hardly ecstatic, and he asked Fatio not to condemn him before understanding him. Especially troubling was the excessive amount of void that Fatio had designed into his system, and the fact that over time Fatio's theory entailed an increasing build up of matter on the surface of the planet. In his reply Fatio defended his theory with vigour but was effusive with compliments for Huygens. Nevertheless, he was forced to say that Huygens had mistaken his comments as an objection to his treatise; Huygens had done him a great honour in proposing objections to his theory, and infelicities in his responses to Huygens' own theory of Iceland crystal and gravity should be put down to the lack of time he had had to prepare his text. He added that since he had seen Hampden's presentation copy very early on, he had also hoped that his speedy response to Huygens' objections might have been incorporated into the standard print version of the text.[17]

Collaboration

Fatio left for the Netherlands in the spring of 1690 as tutor to two of Hampden's nephews, bearing his theory of gravity and a list of errata to Newton's *Principia*. The need for financial support was clearly pressing, and as before, he viewed his new employment as an unwelcome diversion from his vocation. He complained to his brother Jean-Christophe on 9 June that he had lost the opportunity to write up his treatise on the cause of gravity, while there is an apocalyptic tone in a letter written to his friend Nicolas Tourton soon afterwards, instructing Tourton to leave a box of Fatio's mathematical papers with Newton as a sort of 'mathematical legacy'. In two letters written in July he told Huygens that his entourage had decided to stay a few months in Utrecht, and that his teaching duties no longer left him master of himself. Huygens, he wrote, should know how badly Fatio wanted to be close to him, preferably in the 'Hermitage' at Hofwijk. Although there is evidence that Fatio was suffering from depression

and religious doubts for much of this period, his letters indicate that he perceived the lack of space and time for producing his own scholarly work as the chief cause of his existential angst – a situation that could only be assuaged by being close to a patron.[18]

Fatio's wish was granted early in the following year. From February 1691 he and Huygens worked closely together on a series of different topics, including discussing errata to the *Principia*, the cause of colours and gravity, and most importantly, mathematical techniques. These concerned the determination of methods for finding tangents and the development of Fatio's 'Rule' for finding exact differential equations by multiplying equations by the integrating factor $x^m y^n$. In May Fatio told Boyle that he had reawakened Huygens' passion for physics and mathematics, which had been stifled due to a lack of suitable encouragement from other people. However, whether or not Fatio knew it, his contribution was not as great as he had wished. Huygens had been engaged in serious mathematical and scientific discussions with Leibniz for over a year, much of which concerned their responses to themes in Newton's *Principia*. Moreover, under the tuition of Johann Bernoulli (1667–1748), the Marquis de l'Hôpital (1661–1704) had emerged as a major mathematical correspondent who gradually supplanted Fatio's place in Huygens' world.[19]

Mathematical secrecy and a proliferation of circulating problems and solutions characterised correspondence between mathematicians in this period. Since Leibniz had referred to his own excellence in the area of the inverse problem of tangents, Huygens told him at the end of 1690 about Fatio's work on the same topic. When Leibniz asked him the following February if Fatio's work in this area had satisfied him, Huygens informed Leibniz that Fatio was now at The Hague and had visited him several times. Fatio had apparently perfected his method up to a certain point; it did not require tables (which Leibniz had claimed were required for his own method), but it could not deal with roots containing unknowns. Leibniz was unwilling to release his own technique but Huygens asked him if he could provide an integral solution to a curve that Huygens had nominated, and which Fatio had been unable to solve. This would at least clarify the issue as to how their techniques differed. Leibniz in turn mentioned his esteem for Fatio and indicated that some sort of exchange of methods would also be congenial. Having said that, to show Fatio that the curve in question was squarable, Leibniz included his own solution, recasting Huygens' original remarks to make it appear that Fatio had thought it could not be done *because* he himself had not succeeded.[20]

Huygens' personal journal shows how closely he and Fatio cooperated on different problems in the spring of 1691, many of which were on applications of Fatio's 'Rule'. At various points he indicated to Leibniz that he and Fatio were engaged in collaborative work, although Fatio's notes indicate that he operated more easily in the language of fluxions. In early May Huygens implied that both the methods of Leibniz and Fatio were equally meritorious, and again called for Leibniz to send the explication of his technique. While he admired the power of Leibniz's method, he told Leibniz that he should be less opaque in what he sent and should not assume that Huygens and Fatio understood his differential calculus. Throughout the summer, Fatio continued to work with Huygens, and all three men consistently raised the question of exchanging methods. Recognizing how close Fatio was to Huygens, Leibniz suggested in September that both he and Fatio should send their methods to an independent person in Bremen, so that the transaction could be effected.[21]

Mathematical merchandise

Fatio returned abruptly from The Hague at the start of September 1691, lodging once more in Suffolk Street. He explained his return to Newton as being caused by the death of one of his pupils from consumption and offered to travel to Cambridge to let Newton in on the marvellous secret of some 'metallick remedys' that had been prepared by a friend of his. A few days later he told Huygens that he had left The Hague in such a hurry that he had not had time to pick up Huygens' 'orders' for his visit to England; moreover, he had left behind his list of *Principia* errata and asked Huygens to send it, presumably in preparation for his meeting with Newton. In reply Huygens mentioned that he had searched for Fatio a fortnight earlier in order to give him the errata, but had failed to locate him. He did prompt Leibniz about the exchange of methods in November, noting that Fatio had taken back with him the original letter explaining his rule. This letter, he said, had been so seriously altered as a result of their collaborative work over the summer, that it had become something entirely different from the original. Now he lacked a clear statement of Fatio's rule, and would have to deduce it from the various problems on which they had been working.[22]

Fatio's return to England coincided with Newton's resumption of intense mathematical activity. On the one hand he had been spurred into action by the imminent publication by the Scottish mathematician David Gregory (1659–1708) of a general method for integration by series, a move that was embedded in a complex and sensitive web of intellectual property issues. Fatio himself now drew a willing Newton into his own campaign against Leibniz, and as a result of these twin promptings Newton was galvanized into writing a general treatment of integration ('De quadratura curvarum'). In this he developed some of the techniques underlying the second letter he had sent Leibniz in 1676 (the 'Epistola posterior') and he dealt extensively with the inverse problem of tangents.[23]

In a letter to Fatio of early December, Huygens also mentioned that he had now received an account – of sorts – of Leibniz's inverse method of tangents. This was prompted by his irritation at Leibniz's offer to have the matter handled by a third party, as if, Huygens noted, Leibniz doubted Huygens' word. However, Huygens told Fatio that Leibniz's explanation was obscure, and that he hadn't yet got to the bottom of it. Ominously, he told Fatio that since the latter was less versed than Huygens in the differential calculus, it would not be useful to pass on what Leibniz had sent him, at least until he got clarification from Leibniz. Again Huygens noted diplomatically that although Leibniz's method did not exclude roots, Fatio's technique could resolve 'an infinity' of different cases.[24]

Fatio had presumably already seen some or all of 'De quadratura' by the time he replied to Huygens in the middle of December. For the first time he displayed irritation with Huygens, noting that he *did* understand the differential calculus *'fort bien'*. This was despite the notorious errors that had marred the initial printing of Leibniz's method for the differential calculus in 1684 – so numerous, Fatio claimed, that one could almost believe they had been made by design. Referring to the famous 'fluxions' Lemma (book 2, lemma 2) in the *Principia*, he stated that he believed Newton was *'sans difficulté'* the first author of the differential calculus, and that he knew it as well as or better than Leibniz did. At the end of December Fatio was making these views known to David Gregory, adding for good measure that he knew the inverse problem of tangents better than Leibniz. However, Newton knew everything.[25]

Trouble with Newton

As Fatio ignited the first flames of the priority dispute over the invention of calculus, Newton's intellectual rigours and his failure to obtain a key position in London both took their toll. In December he had a brief exchange with Locke over the possibility of obtaining a position at Charterhouse and at the end of the month he travelled to London for the funeral of Robert Boyle. He dined with Samuel Pepys (1633–1703) and John Evelyn (1620–1706) on 9 January but fell into a paranoid and melancholy mood soon afterwards. A week later, Locke's friend Robert Pawling told him that he had seen Newton 'up two pairs of Stairs in a pittifull room' in Suffolk Street, presumably in Fatio's lodgings. Pawling clearly implied that the source of Newton's angst was his inability to land a senior position in the capital but aside from this, there were a series of intellectual problems that vexed him at this time. Some of these involved Locke, who had been left a recipe for Boyle's 'red earth' along with some specimens. Over the next few months Newton and Locke exchanged letters on the topic, and also on the issue of suppressing Newton's provocative essay on the Trinitarian corruption of Scripture.[26]

Newton had also embarked on the preparation of a second edition of the *Principia*. Huygens asked Fatio about this in early December 1691, partly as a way of accommodating the growing number of errata (most of which Fatio had passed on to him). Fatio in turn gave an impression of great intimacy with Newton, emphasizing his own central role in any future edition. Mixing boastful comments with expressions of humility, he told Huygens that he would want to add certain elements to the edition – by which he undoubtedly meant his own theory of gravitation. There was also the issue of the list of errata, which was expanding as he ploughed his way through it. Nor was this all, for most ambitiously he proposed a truncated folio edition that could be read in a fraction of the time that one required to read the present quarto. He doubted, however, whether his health or financial situation would allow him to have the leisure required for the work. Gregory heard from Fatio at the end of the month that such an edition was being planned, along with a preface by Fatio that gave a physical explanation of gravity. Gregory took down a detailed description from Fatio of his theory but also recorded, presumably from the lips of Halley, that Newton and Halley mocked it.[27]

In early February 1692 Huygens relayed the less inflammatory con-

tents of Fatio's letter to Leibniz and immediately afterwards told Fatio that undertaking a new edition of the *Principia* should not be carried out to the detriment of his health. As for underwriting the edition, there were surely English booksellers who would back an enterprise of this nature – such people certainly existed in Holland. In any case it could be done by subscription. As for the exchange, Huygens lamented that both men believed they could find what was lacking from the other's method with a minimum of effort. He added that he hoped Fatio's work would appear in the forthcoming book on curves by Newton that Fatio had mentioned to Constantijn. Finally, he noted – not unreasonably – that he thought that in the place in the *Principia* to which Fatio had referred, Newton had recognized that Leibniz had arrived at the same thing at roughly the same time as him (*'a peu pres que luy'*).[28]

Fatio's request to Huygens in early February 1692 that he locate Fatio's manuscript on gravity (which like the errata, he assumed he had left in the Netherlands), indicates that it was only now that he had resumed serious work on the topic. However, Huygens' lukewarm comment about Newton's chronological priority in formulating the core elements of the differential calculus provoked Fatio into developing more extreme remarks regarding the way in which Leibniz had likely come across the basic theorems of the calculus. The route, Fatio went on, must have been via the two *'epistolae'* sent to Leibniz by Newton in 1676 – Leibniz's 'rules' appeared soon afterwards, without rendering to Newton the just credit that he deserved. In driving home the additional point that the Leibnizian calculus was an imperfect copy, Fatio was even prepared to destroy his own claims to originality, since (he continued) Newton had everything Leibniz 'seemed' to have as well as everything Fatio had that Leibniz did not. Newton had gone 'infinitely further than us', Fatio said, both as regards quadratures and also on the inverse problem of tangents. He could find the equation of a curve from the fluxion of a fluxion (Fatio said that he was using Newton's terms) and even from the fluxion of a fluxion of a fluxion. In Newton, Fatio continued, he had found 'an incomparable guide', both more enlightened and more generous than Leibniz. He was not, he said, upset to have avoided engaging in an exchange of mathematical propositions as if they were merchandise, for Leibniz always set a very high price on his commodities.[29]

As remarkable as the claims about Leibniz's unacknowledged debt to Newton was Fatio's revelation to Huygens that Newton had produced a number of additional 'classical scholia' for the second edition of the *Principia*. He apparently believed that Pythagoras, Plato and others possessed all the demonstrations he had given in the *Principia*, and that these were all grounded on the inverse square law. In reply Huygens noted that despite the fact that the ancients had access to the Copernican system, Newton had given them far too much credit. In early March 1692 Fatio wrote to say that Newton had gone cold on the idea of publishing his tract on quadratures. This was, he said, because of the latter's unwillingness to engage in the trouble that would result, though the mathematical world would lose greatly if it did not appear. If he hadn't leafed through it he would have liked to pursue the mathematical ideas he had been working on in Holland, which – he reminded Huygens – they had often undertaken together. He didn't despair of finding everything that Leibniz's method lacked, and even more. But he had been chilled (*'glacé'*) seeing the work of Newton, and had reproached him for rendering all Fatio's own work useless, and for not wanting to leave anything to do by his friends who came after him.[30]

Huygens replied at the end of March to say that there was no excuse for Newton's mathematical treatise not to appear, and that Fatio himself should take care of the publication, implying that it would be much easier than the task he had set himself with the *Principia*. He added that he had offered to explain Fatio's method to Leibniz ('because I wanted him to acknowledge that he didn't know it') but was still waiting for his response. Leibniz told Huygens that he was grateful to Fatio for the offer but because he believed he knew the basis of it, and was after a more general method, he wouldn't bother him about it. Huygens lamented at the start of May that both Fatio and Leibniz had distanced themselves from wanting to learn from each other, whereas he himself had wanted to learn from both of them.[31]

Personal business

By March 1692, Fatio's interests had begun to lurch sideways. He told the Count of Monros that he was interested in buying a tower in Delft with various tools that were being used for working on the lenses of simple microscopes. He may have wanted to involve himself in the construction of lenses, a subject on which Huygens and his brother were experts – and if so, Huygens told him, he was wasting his talents. More likely, Fatio was already interested in teaming up with Huguenot

watchmakers in London, an activity that he would take very seriously over the following decade. However, in early May academic employment beckoned once more and Huygens wrote saying that he strongly supported a renewed effort to procure a chair in mathematics for Fatio in the Athenaeum Illustre (Illustrious School) of Amsterdam, which the representative of the Court of Brabant in The Hague, Salomon Dierquens, was trying to arrange.[32]

Fatio now reconsidered his aloofness regarding the editorship of the *Principia*. Idleness or 'other studies' often distracted him, he told Huygens, but after these had abated, his desire to see the new edition to press was redoubled. He had come to terms with many of the most intractable parts of the book, which led him to believe that if he had the time to give it the necessary attention he could understand the book perfectly. Perhaps the old team could be reassembled. Huygens could undertake some of the other sections and it would not be difficult to complete the entire task in a short space of time. They could inform each other about the difficult sections they had encountered and jointly come to terms with the book that was assuredly very excellent but at the same time extremely obscure. Perhaps, when the book was nearly ready, Fatio could spend some time in Amsterdam.[33]

Immediately after he had tantalized Huygens with his possible translation to the Netherlands, Fatio was in contact with his other patron, perhaps to inquire about some of the passages he had mentioned to Huygens. In the middle of May he wrote to Newton asking him if he could take a room near Trinity College and presumably this request was granted. His precise movements over the summer of 1692 are unknown, although almost certainly he spent it in London. In September Fatio again enjoyed a brief visit to Cambridge, but on his return to the metropolis he told Newton that he had contracted a serious cold, which had worsened to the point where he was probably gravely ill. In a melodramatic flourish he told Newton that despite immense physical turmoil his soul was at rest, a fact that he largely attributed to Newton. None of the conventional remedies had worked, though an emergency ventral paracentesis might do the trick; if he were to die, he wished that Newton would take care of his brother.[34]

Fatio's problems elicited an immediate reply from Newton, who showed great concern for his well-being and asked for more details about his brother. Fatio recovered somewhat towards the end of 1692 but his friend Jean Alphonse Turretini told Newton in January 1693 that Fatio was still suffering from a serious cold, and was considering returning to Geneva. Newton invited him to Cambridge in order to escape the dank London air, but Fatio replied that the recent death of his mother made the trip to Geneva more pressing. However, Dierquens' son visited Newton in early February and informed him that the offer of the Amsterdam professorship was still live. In a comment that is difficult to interpret, Newton told Fatio soon afterwards that if he did get the Dutch position, Newton would be glad to have him so close to England.[35]

Perhaps all this could be avoided. In March 1693 Newton revealed that he had been trying to organize financial support to keep Fatio at Cambridge, and the latter confirmed that he would prefer to stay in England rather than return to Switzerland. Hopefully, he said, he could stay in the Trinity chamber next to Newton's and in April he remarked: 'I could wish Sir to live all my life, or the greatest part of it, with you, if it was possible'. Over the spring Fatio's poor health, particularly his chronic cold, various schemes to make money through alchemical knowledge, and his lack of money remained central themes in a flurry of correspondence between the two men. Newton left for London on 30 May, presumably to spend time with Fatio and chat about the latter's medical and alchemical projects. He returned to Cambridge after a week, but what happened in the next few months remains shrouded in mystery. By the late summer he was in a full-blown mental crisis, which was not resolved until much later in the year, although a letter written by Fatio in August makes it highly unlikely that his problems were caused by any friction between them. Nevertheless, they were never on such close terms again, and indeed evidence of any personal contact between them after this point is sparse.[36]

On the European mathematical scene, Fatio was now fading from view, although Newton's work moved to the centre of attention. From late 1692, De l'Hôpital probed Huygens for information about what Newton had to say about the inverse method of tangents. In a letter to De l'Hôpital in October, Huygens had placed Fatio's and Leibniz's work on the topic in the same bracket as Newton's, adding, however, Fatio's remark that Newton knew more on the subject than Leibniz and Fatio combined. Soon afterwards the Marquis heard that a new edition of the *Principia* was to appear *'plus à la porté de tout le monde'* and that a treatise by Fatio on gravity was imminent. Indeed, Fatio was reworking his (apparently rediscovered) treatise on gravity in October

1692, in another abortive attempt to resurrect the idea of a new edition of the *Principia*, and he was probably the source for the Marquis' information.[37]

In the gap created by Fatio's apparent departure from the Republic of Letters, David Gregory now emerged as chief spokesman for Newton and as the likely editor for the second edition of the *Principia*. Gregory spent time in May and June 1693 with Huygens at Hofwijk, discussing mathematics, relative and absolute motion, and Newton's theory of light. He sent Huygens his own series method of quadratures in July, and the following month sent Huygens the 'method' of Newton that was about to appear in Wallis' imminent publication. By now Fatio's method was no longer secret and indeed Huygens had suggested to De l'Hôpital the previous December that the latter had probably discovered it independently. In May Huygens had failed to use it in order to solve a problem posed by De l'Hôpital, and he passed on the rule to the Frenchman in July; in turn, the latter wrote that it was much more restricted in its use than what he himself had sent Huygens. Having removed its protective cover of secrecy, Huygens tried to safeguard Fatio's priority and referred to fruitful work he had done together with Fatio two years earlier, arguing that the rule was useful and might work in cases where De l'Hôpital's did not. It continued to receive equal billing with Leibniz's 'method' in another letter sent by Huygens to De l'Hôpital in September 1693.[38]

Retreat

Fatio's break from Newton did not result in a closer relationship with Huygens. Indeed, there is no evidence of communication between them between May 1692 and November 1693, when Huygens wrote to Fatio saying that he had not heard from him for some time. Huygens said that he had feared that Fatio had contracted a new illness, though he added that he had been occasionally kept up to date with Fatio's news by Monros. However, as Fatio probably surmised, it was Newton, rather than himself, who seems to have been the focus of Huygens' interest. He prompted Fatio to say more about whether he was to edit a new edition of the *Principia*, and whether he'd learned anything from conversations with this 'excellent man'. He also asked Fatio to let him know Newton's thoughts touching quadratures and the inverse rule of tangents.[39]

Fatio received the letter and made notes on it, but with a sense of déjà vu Constantijn told his brother that he had struggled to deliver it after trying for some time to 'disinter' the Swiss from the great city. Fatio, he said, was now a tutor to an aristocrat whose name Constantijn had forgotten (actually the Duke of Bedford), and he lamented that fortune did not do justice to merit. For the first time Christiaan displayed a high degree of exasperation with Fatio, for he had presumably been told to expect the letter and Christiaan had supposed he would fetch it from Constantijn himself. Huygens never wrote to him again but, surprisingly, Fatio was contacted in the spring of 1694 by Leibniz, who had asked Herr de Beyrie, resident in London for the House of Brunswick, to probe Fatio for information on Newton's opinion regarding various points articulated by Huygens in his *Traité*. In his reply, Fatio rehearsed the main points of agreement between himself and Newton and noted that Huygens had been persuaded by Fatio's response to criticisms of his theory of gravity.[40]

Leibniz conveyed the contents of Fatio's letter to Huygens at the end of April 1694, adding his own doubts about the Newtonian system. Huygens in turn told him that he admired the power of Leibniz's calculus, and had just received the new edition of Wallis' *Algebra* containing some new material on series by Newton. These had differential equations that resembled Leibniz's except for the notation. Fatio's mechanical account of gravity was dismissed by Huygens as even more 'chimerical' than his theory of light. As for Fatio's claim that Huygens had been satisfied by his response to the Dutchman's criticisms of his theory, this was readily dismissed. Fatio's suggestion that the deposition of material on the surface of the Earth would never result in a considerable bulk on account of its fineness, was neither reasonable nor probable.[41]

As his antipathy to the views of Newton and Fatio hardened, Huygens received the dramatic news at the end of May 1694 that Newton had suffered an *'atteinte de phrenesie'*, which had incapacitated him for the previous eighteen months. On receiving the news, Leibniz remarked that he thought the comments by Fatio he had sent on earlier had been 'reserved' and 'enigmatic', and indeed they were simply a curt rehash of what he had told Huygens over the previous three years. Fatio had seemingly cut off contact with his erstwhile patrons for almost a year, although he did compose a letter explaining his situation as a tutor to Huygens in September 1694, ostensibly in response to the one sent almost a year earlier.[42]

Patronage games

The relationship between Fatio, Newton and Huygens constituted a highly significant two-way conduit for the flow of ideas between Britain and the Netherlands. Apart from very occasional releases of information in books and correspondence, Newton used disciples such as Fatio and Gregory to disseminate some of his private findings and beliefs to continental scholars. Huygens had closer connections with French, Dutch and German scholars, but used intermediaries such as Fatio, William Stanley and his own brother to communicate his ideas and publications. There were other Anglo-Dutch networks at the time, including the correspondence between Antoni van Leeuwenhoek (1632–1723) and the Royal Society, and the regular pilgrimages made by Scottish students to study medicine at Leiden. Nevertheless, the nexus created by Fatio's intimate proximity to both Newton and Huygens, facilitated by his ability to gain their utmost trust, constitutes a very rare event in the history of science. Thanks to Fatio, the two dominant intellectual figures of the day could communicate without ever having to correspond, or with the exception of the summer of 1689, meet with each other.

Fatio proved unable to sustain the role he had carved out for himself as go-between and client of the two super-patrons. By 1693 or even earlier, his dreams of being a big player in the scholarly firmament had evaporated. Although Fatio was no longer Newton's favourite, he was not completely expunged from Newton's wider circle of acolytes and for a number of decades he was linked to key members of Newton's circle. Huygens' death in 1695 prevented any further connection between them but in any case they had had little or no serious contact for some years. It is important to view Fatio's career from the perspective of Huygens and Newton. For many years he was the spokesman for both men. He translated Huygens' work into English for Newton, and communicated Newton's views to Huygens; to both of them he appeared to be an inordinately talented disciple. Fatio communicated with each scholar in a language of intimacy, frequently asking if he could lodge and work in close proximity to both bachelors, and he moulded himself into a trustworthy collaborator. Newton and Huygens freely reciprocated this attentiveness, and both were intensely and actively concerned about Fatio's well-being.

Proximity to Newton was not for the faint-hearted. The new edition of the *Principia* offered Fatio a chance both to transform the masterpiece, and to incorporate into it his theory of gravity. This would have made the *Principia* much more of a work of his own, and would have made it accessible to a much larger audience. There is no unambiguous evidence concerning what Newton thought about this undertaking, since Fatio's letters are the chief source of our evidence for this episode. Newton seems briefly to have supported the project at the end of 1691 but very soon afterwards thought Fatio's theory of gravity was risible. In any case, having frequently advertised his role in a forthcoming edition, it did Fatio's reputation no favours when the edition failed to materialize. As for the theory of gravity, it proved impossible to concoct a plausible hypothesis that could satisfy the twin demands of both mechanical and attractionist approaches. Regarding mathematics, as Fatio correctly surmised, Newton had almost nothing to learn from him.

Huygens initially nurtured Fatio's talent, and in the late 1680s the latter enjoyed a reputation on the circuit as an expert in the business of determining tangents to complex curves. However, Fatio's most valuable intellectual property involved his rule for giving solutions to some inverse tangent problems. Their 1691 collaboration on various applications that stemmed from this reprised the working relationship they had enjoyed four years earlier. However, Fatio was unable to generate academic credibility from this partnership and indeed, lost the favour of his patron. Huygens found him to be an untrustworthy correspondent whose shifting addresses made it impossible to communicate with him on a sensible basis. Moreover, Huygens never accepted the solidity of his theory of gravity. Although he continued to value and defend Fatio's method for the inverse problem of tangents, he was responsible for revealing it to De l'Hôpital, thus neutering its value.

Much of Fatio's downfall should be attributed to the irreconcilable demands of wanting to serve and please his two masters, while needing distance from them to make his own way. However, arguably the central relationship in this period was with Leibniz, and it was Fatio's misfortune to have tried to strut the mathematical stage at the same time as Leibniz and his disciples. Fatio's mathematical capital was relatively worthless once Leibniz refused to engage in an exchange of methods, and was absolutely so after he had seen Newton's 'De quadratura'. As Fatio's credit withered, he could at least ensure that Leibniz was brought down with him. The letters to Huygens in the winter of 1691–1692 show that diminishing Leibniz's credibility to the infinite-

ly small required elevating Newton's reputation to the infinitely large. Fatio's dual claims about Leibniz's scurrilous behaviour and Newton's transcendent genius must have rung hollow to Huygens, for thanks to Newton's decision to withhold much of his work, he was unable to appreciate just how far Newton had progressed in mathematics. That said, he had been given an insight into the way things would develop after his own death. Two decades later, Newton, by now president of the Royal Society, assailed Leibniz using exactly the same arguments and tactics adopted by Fatio in his letters to Huygens.

Notes

1 For Fatio's career, see: C. Domson, *Nicolas Fatio de Duillier and the prophets of London* (New York 1981); F. Manuel, *A portrait of Isaac Newton* (Cambridge, MA 1968), pp. 191–202; S. Mandelbrote, 'The heterodox career of Nicolas Fatio de Duillier' in: J. Brooke and I. Maclean (eds), *Heterodoxy in early modern science and religion* (Oxford 2005), pp. 263–296. I am extremely grateful to the editors of this book for various comments on earlier drafts.

2 See Domson, *Fatio* (note 1), pp. 6–14 and Mandelbrote, 'Heterodox career' (note 1), pp. 273–277.

3 For his parents' views on a suitable career, see Mandelbrote, 'Heterodox career' (note 1), pp. 273–274.

4 See Ch. Huygens, *Oeuvres complètes de Christiaan Huygens,* 22 vols (The Hague, 1888–1950), vol. 9, pp. 117–120 (cf. 9: 169 for the inverse problem), 167–171 and 219–221 (footnote 14).

5 See G. Burnet, *Bishop Burnet's Travels Through France, Italy, Germany, and Switzerland* (London 1750), p. 14; Domson, *Fatio* (note 1), p. 15; Huygens, *Oeuvres complètes* (note 4), vol. 9, pp. 167–169 and 190–191. All dates in the main text are Old Style (O.S.) unless otherwise indicated.

6 Fatio to Boyle, 21 January 1687/1688; M. Hunter et al. (eds), *The correspondence of Robert Boyle,* 6 vols (London 2001), vol. 6, p. 246; Fatio to Huygens, 28 April/9 May 1688; Huygens, *Oeuvres complètes* (note 4), vol. 9, pp. 296–297.

7 Domson, *Fatio* (note 1), p. 17; R. Gagnebin, 'De la cause de la pesanteur. Mémoire de Nicolas Fatio de Duillier. presenté à la Royal Society le 26 février 1690', *Notes and records of the Royal Society* 6 (1948), pp. 114–115.

8 See H.M. Snelders, 'Christian Huygens and Newton's theory of gravitation', *Notes and records of the Royal Society* 43 (1989), pp. 209–222, esp. pp. 210–211 and 215–219; C.D. Andriesse, *Huygens: the man behind the principle* (Cambridge 2005), pp. 352–353. Huygens' comments on Newton's treatment of vortices are at Huygens, *Oeuvres complètes* (note 4), vol. 21, pp. 143, 408–412 and 437; for the report, see ibidem, vol. 9, pp. 272–291. In the latter Huygens claimed optimistically that by means of his pendulums one might determine longitude to within about 20 miles.

9 See H.W. Turnbull et al. (eds), *The correspondence of Isaac Newton,* 7 vols (Cambridge, 1959–1981), vol. 3, p. 45.

10 See Domson, *Fatio* (note 1), pp. 32–33 and 46; Fatio's figure was worth about 25,000 UK pounds in contemporary money.

11 See Huygens, *Oeuvres complètes* (note 4), vol. 9, pp. 305 and 312–313. In the seventeenth century the Old Style (O.S.) Julian calendar used in England was ten days behind the Gregorian calendar generally in use in the Republic of Letters; the dates used in this paper are Gregorian unless otherwise stated.

12 Huygens, *Oeuvres complètes* (note 4), vol. 9, pp. 321–330 (for Newton's proof), 333–334 and 334–355; vol. 22, pp. 743–749 (for Christiaan's diary); Andriesse, *Huygens* (note 8), pp. 355–360 and 366–368; R.S. Westfall, *Never at rest. a biography of Isaac Newton* (Cambridge 1980), p. 520. See also L. Jardine, *Going Dutch: how England plundered Holland's glory* (London 2008).

13 Huygens, *Oeuvres complètes* (note 4), vol. 9, pp. 353–354 and 357–359. Huygens' father, Constantijn Huygens Sr, had died in March 1687.

14 See Huygens, *Oeuvres complètes* (note 4), vol. 9, pp. 86, 361–362, 370–371 and 373–374. For the various addresses in which Fatio lodged during his stays in London, see ibidem, vol. 9, pp. 171, 190, 360 and 380–381; Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, pp. 241 and 243, and Bloomsbury Book Auctions Sale, 14 February 1991 (lot 390). I am grateful to Scott Mandelbrote for bringing this letter to my attention. For Fatio's forwarding address at Tourton and partners, see ibidem, vol. 3, pp. 45 and 233.

15 Gagnebin, 'Mémoire' (note 7), pp. 115–118; Huygens, *Oeuvres complètes* (note 4), vol. 9, pp. 381–389. For an analysis of Fatio's theory, see H. Zehe, 'Die Gravitationstheorie des Nicolaus Fatio de Duillier', *Archives for the history of the exact sciences* 28 (1983), pp. 1–23.

16 Huygens, *Oeuvres complètes* (note 4), vol. 9, pp. 379–380, 381–389 and 407–408; Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, pp. 390–391. See Westfall, *Never at rest* (note 2), p. 496 and I.B. Cohen, *Introduction to Newton's* Principia (Cambridge 1971), pp. 177–179, esp. 179n3 and 184–188.

17 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 388–389, 391–393, 408–411 and 413.

18 Huygens, *Oeuvres complètes* (note 4), vol. 9, pp. 388, 392, 444–445 and 464; Gagnebin, 'Mémoire' (note 7), p. 110; Manuel, *Portrait* (note 1), pp. 193–195; Domson, *Fatio* (note 1), pp. 43–44.

19 Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, p. 79; Hunter, *Correspondence of Robert Boyle* (note 6), vol. 6, p. 333. For Leibniz's response to the *Principia*, see D. Bertoloni Meli, *Equivalence and priority: Newton versus Leibniz* (Cambridge 1992). For Fatio's rule, see Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 21 and 74–76 (footnotes 5 and 9), and Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, pp. 78n4 and 195n7.

20 Huygens, *Oeuvres complètes* (note 4), vol. 9, p. 571, 10, pp. 15, 21–22 and 50–51.

21 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 76–77 (for Fatio's use of fluxions), 77–78, 86–88, 93–94, 99, 109–112, 127–129 and 161–162. For Huygens' reference to his joint work with Fatio, see ibidem, vol. 10, pp. 22, 87n9 and 190.

22 See William Andrews Clark Memorial Library, Ms. F253L 1691; Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 145–146, 163 and p. 76 note 10.

23 Turnbull, *Correspondence of Isaac Newton* (note 9), pp. 169–170, 170–171 (with the series at 172–176), 181 and 181–183 (the surviving version of Newton's letter is a draft). For the original treatise, see D.T. Whiteside (ed.), *The mathematical papers of Isaac Newton*, 8 vols (Cambridge 1967–1981), vol. 7, pp. 24–48 and 48–128 (and p. 79 for a reference to Fatio). Compare with Westfall, *Never at rest* (note 10), pp. 513–516.

24 Huygens, *Oeuvres complètes* (note 4), vol. 10, p. 190, pp. 196–197 (and cf. 197–202 for Leibniz's method) and pp. 209–210.

25 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 213–215; Gregory memorandum, 28 December 1691; Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, p. 191.

26 Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, pp. 184–185 and 185–186; Pawling to Locke, 16 January 1691/2, E.S. de Beer (ed.), *The correspondence of John Locke*, 8 vols (Oxford 1976–1989), vol. 4, pp. 353–354. The Trinity College Exit/Redit book indicates that Newton returned to Cambridge on 21 January.

27 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 209–210 and 213–215; David Gregory memorandum, 28 December 1691 (O.S.), in Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, p. 191 (and ibidem, vol. 3, p. 70n1, for the memorandum of 27 December recording Fatio's detailed description). Cohen points out that Fatio's improvements, visible in his own copy, would have made a significant improvement to the 'look' of the *Principia*; see Cohen, *Introduction* (note 16), pp. 181–183.

28 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 239, 241–242, 257 and 271. Constantijn mentioned Newton's treatise in a letter of 16/26 January, presumably as a result of a visit by Fatio on 16/26 December; see ibidem, 10, pp. 236 and 214n4.

29 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 257–259. Huygens responded that he did not understand what was meant by a fluxion of a fluxion; see Gagnebin, 'Mémoire' (note 7), p. 159.

30 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 241–242, 257, 268–270 and 271–272; Gagnebin, 'Mémoire' (note 7), pp. 158–60.

31 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 276–280, 285 and 287. For Huygens' view of Leibniz's behaviour see ibidem, vol. 10, p. 439.

32 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 276–280, 285 and 287–288; for the 'lost' treatise see ibidem, vol. 10, pp. 257, 271.

33 Ibidem, vol. 22, pp. 158–159; Cohen, *Introduction* (note 16), pp. 181–183.

34 William Andrews Clark Memorial Library, Ms. F253L 1692; Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, pp. 229–230. Newton's (undated) suggestion that Fatio lodge with him is to be found at New College Ms. 361.3 fol. 34r. More generally, see Westfall, *Never at rest* (note 12), pp. 531–539; Manuel, *Portrait* (note 1), pp. 192–204.

35 Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, pp. 231–233, 241–244 and 245; Bloomsbury Book Auctions Sale, 14 February 1991 (lot 390).

36 Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, pp. 262, 263 and 391; William Andrews Clark Memorial Library, Ms. F253L 1693. See also Westfall, *Never at rest* (note 11), pp. 533–535.

37 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 327, 346 and 393.

38 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 350, 393, 447n6, 452 and 464–468 (for Fatio's rule and cf. 491–4), 471–473, 485 and 493–494; Turnbull, *Correspondence of Isaac Newton* (note 9), vol. 3, pp. 272–274 and 275–278. See also R. Vermij and J. van Maanen, 'An unpublished autograph by Christaan Huygens: his letter to David Gregory of 19 January 1694', *Annals of science* 49 (1992), pp. 507–523, esp. 511 and 517–518.

39 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 567–569.

40 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 581–582, 583–584, 598–599, 599–600, 605–606 and 606–608; and vol. 22, pp. 162–163.

41 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 600–605 and 609–615; and vol. 22, pp. 162–163.

42 Huygens, *Oeuvres complètes* (note 4), vol. 10, pp. 615–616, 617–619 and 639–646, esp. 643–644.